Ontario

FUTURE SCENARIOS FOR ONTARIO

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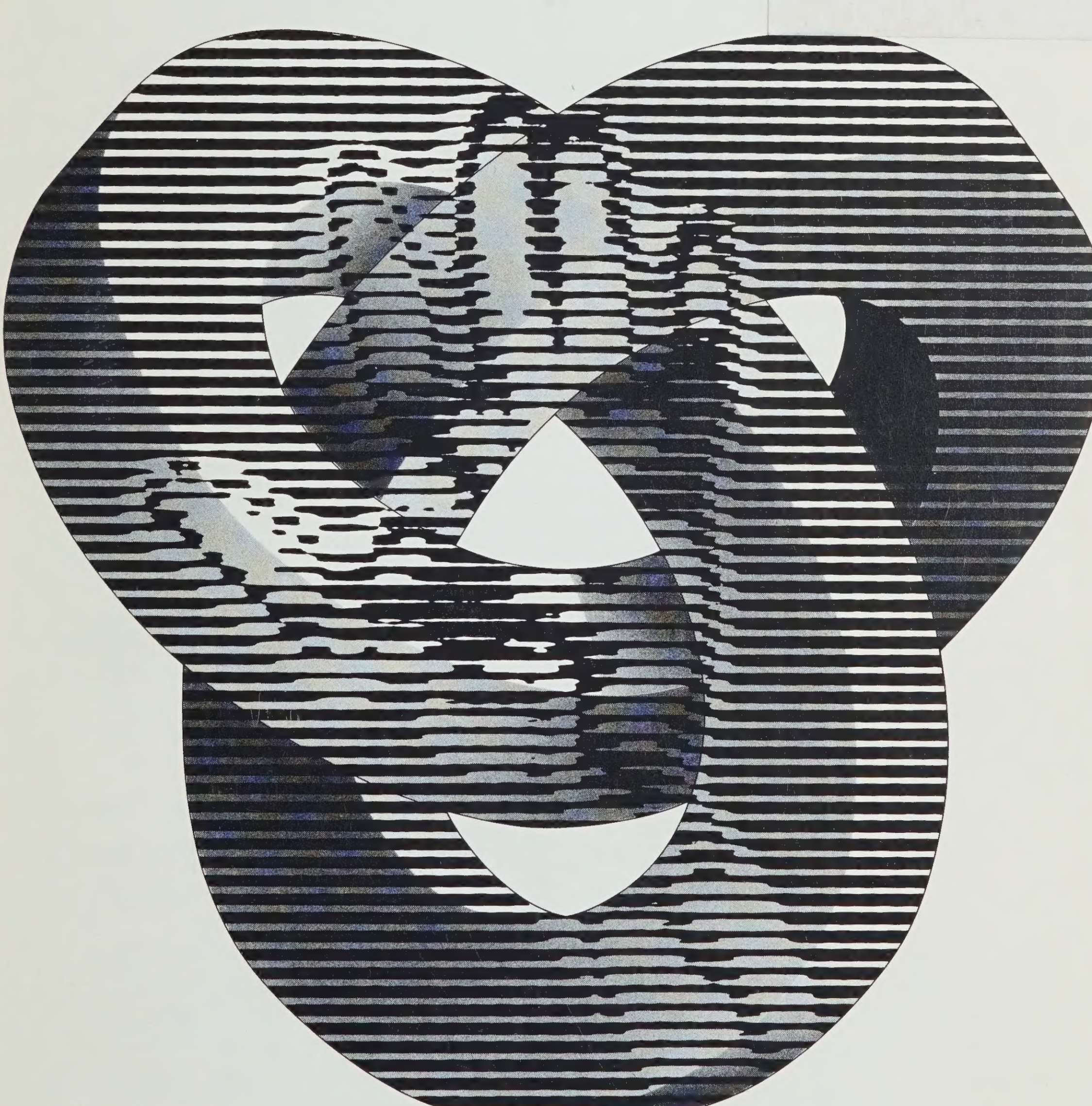

Preliminary Assessment of New Technologies

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Authors (name, title and/or organisation):
R. Voyer and L. Edwards, Nordicity Group Ltd., Management Consultants, Ottawa and Toronto, Ontario

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Abstract:

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Applications for these technologies are discussed, along with the state of development in Ontario, and the province's strengths and weaknesses are compared to the international scene. The significance of implementing or not implementing new technology is postulated under two approaches: business-as-usual and an aggressive stance.

Key Words: aerospace, biotechnology, new energy, magnetics, micro-electronics, oceanography, robotics, communications technology

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-- Preliminary Assessment of New Technologies --

R. Voyer and L. Edwards
Nordicity Group Ltd.
Management Consultants
Ottawa and Toronto, Ontario

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The Editor, Technical Publications
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FOREWORD

As part of the Transportation Outlooks project, seven papers were commissioned, dealing with well-defined themes of major significance to the future development of Ontario. Under the main heading Future Scenarios for Ontario, the titles of the papers are as follows:

1/ The Environment
2/ Resources Sector
3/ Production
4/ Multinational Corporations
5/ Social Values and Behaviour
6/ Political Change
7/ Preliminary Assessment of New Technologies

The papers were commissioned from experts, several of them of national or international renown, in various fields. It is expected that their work, and additional material related to it, will be used in the development of a number of alternative scenarios of Ontario's prospects. The main objectives are to stimulate thinking about the future and to elicit feedback from MTC planners and other users of such information in order to guide further studies of the future, that are both relevant and timely.

It should be noted that these papers, which were completed in June 1982, are primarily the speculations or opinions of experts, not statements of fact. It should also be clear that a different choice of experts would have produced another set of opinions. Part of the process of anticipating future change is the painstaking analysis of detail, including quantitative information, and the expert assessment of emerging and disappearing trends and other qualitative information. Another part is the careful integration and synthesis of all these different types of information. Futures research requires the involvement and participation of all users to improve on the application of futures information to current decision-making.

Most of the reports delineate events as they would develop if Ontario, Canada, and the world were to follow two broadly different futures: low growth and high growth, as described in the following.

Low Growth

This future assumes an economic environment characterized by continued slow economic growth and attempts to reinforce the existing industrial structures globally and locally. The gap between North and South continues to widen, and there is little change in conditions in the Third World. Also, relations between East and West continue to be strained. At the same time, attempts to liberalize trade and capital movements as well as reform the international monetary system will be piecemeal and sporadic.

High Growth

The main features of this environment are more rapid economic growth and attempts to harness the new technologies (e.g., micro-electronics, biotechnology, oceanography, etc.) in building a new industrial structure globally and locally. The assumptions include greater co-operation between East and West, and North and South, with rapid improvements in the conditions of the Third World. At the same time, there will be strong and relatively successful attempts to liberalize trade and capital movements as well as reform the international monetary system.

Two of the reports are based on different pre-conditions. In the case of Preliminary Assessment of New Technologies, the two scenarios were simply omitted, and an assessment was done of the potential of developing a high-technology future for Ontario. The paper Political Change deals with two main scenarios and a third scenario which considers an overlay on each of the preceding two. One pre-condition -- in effect, an amalgamation of two alternatives -- was given for this paper and is as follows.

Assume a competitive world environment (politically and economically) with slow rates of economic growth for most nations, a high priority for more economically successful countries to re-industrialize using high technology, and serious international competition for resources and markets. There will be winners and losers nationally, as well as by and within industrial sectors.

ABSTRACT

This paper provides a preliminary approach or framework for evaluating the following technologies in a 25-year time frame: aerospace, biotechnology, fission/fusion and other new energies, magnetics, micro-electronics, communications, oceanography and robotics.

Applications for these technologies are discussed, along with the state of development in Ontario, and the province's strengths and weaknesses are compared to the international scene. The significance of implementing or not implementing new technology is postulated under two approaches: business-as-usual and an aggressive stance.

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1/ INTRODUCTION

1.1/ Terms of Reference

This paper deals with:

- the potential for social acceptance of the new technologies and the social implications of implementing them; and

- the capital resources required to implement these new technologies and the actors/sources involved in providing them.

The time frame for consideration of the implementation of technologies is 25 years, and while there is no limit on the number of technologies to be reviewed, the following were included for specific evaluation:

- aerospace
- biotechnology
- fission/fusion and other new energies
- magnetics
- micro-electronics
- communications
- oceanography
- robotics

One topic that is very important for Ontario is communications technology, which relates to the micro-electronics and aerospace (i.e., satellites) sectors mentioned above.

1.2/ Assumptions

This paper is based on the following fundamental assumptions about the next 25 years.

1/ Ontario society will continue to be of a "technology-push" nature (i.e., an advanced industrial society). (See Appendix A.)

2/ Most of the technologies to be implemented are already in existence. Development and diffusion of a technology take a long time; however, new applications of a mature technology can occur rapidly.

3/ Ontario's socio-economic structure* will not change dramatically (i.e., a surprise-free future).

4/ Ontario society will continue to exhibit values typical of Western industrialized democracies (e.g., competitiveness, individuality, freedom of expression, etc.).

Also, a technology cannot be separated from the socio-economic context in which it is implemented. The criteria used for the evaluation of a new technology must, therefore, relate closely to the socio-economic context of Ontario. The rationale for these assumptions is assessed in Appendix B.

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*The socio-economic structure of an advanced industrial society such as Ontario is characterized by a relatively large tertiary sector (Appendix A), as well as a high Gross National Product (GNP).

2/ THE METHODOLOGY

The approach taken was to test a new technology against a number of criteria which relate to three Ontario contexts, as follows:

1/ the technological context,
2/ the economic/industrial context, and
3/ the social context.

Specific criteria were established against each of these contexts.

2.1/ The Technological Context

Technological development is intimately related to the stage of development of a given technology and to the technological capability (i.e., resources, skills, or commitment) associated with its development. Two specific criteria relate to this technological dynamic:

1/ **International Strength**
This refers to the current state of development of a technology. Is it still at the laboratory level, development level, early commercialization, or at the large-scale diffusion level? Where, in the world, are the centres of excellence for the technology?

2/ **Ontario Capability**
Given our basic assumption that most of those technologies that will be implemented in the next 25 years are already evident, a viable Ontario capability is a prerequisite to being able to act on the technology.

2.2/ The Economic/Industrial Context

The main criteria relating to this context follow.

- **Ontario's Comparative Advantages**
  In the next 25 years, Ontario will have to build on the following principal comparative advantages:

  - **location**, i.e., proximity to large industrialized markets;
  - **natural resources**, i.e., forestry, minerals, agriculture, water and recreational potential;
  - **industry**, i.e., the concentration of firms in southern Ontario, which provides an important industrial infrastructure; and
  - **tertiary/quaternary sector**, i.e., an extensive capability in professional and specialized support services.

- **Sector on Which the Technology Operates**
  For example, robotics can be applied to a number of sectors ranging from mining to the automobile industry, and its importance will depend on the importance of the sector to Ontario's economy.

- **External Influences and Resulting Positive or Negative Economic Effects**
  For example, the demand for electricity in the U.S. could stimulate the development of nuclear energy in Ontario, while the Japanese automobile industry has a negative impact on Ontario's automobile industry.

2.3/ Social Context

This context has two main components: acceptance and impact of a technology.

Related to <u>acceptance</u> are these principal criteria.

- **Comfort Factor**
  Does the technology fit well with the political and social ethos of Ontario?

- **Capital Requirement**
  Technologies that require modest amounts of capital or can phase in capital in an evolutionary fashion are usually more acceptable than technologies which require large ("lumpy") financial commitments.

- **Policy Environment**
  A supportive, explicit, policy commitment facilitates acceptance.

Related to impact, which is a dependent variable, there are the following key criteria.

- **Transformative Potential**
  Will the implementation of the technology change, in any fundamental way, societal processes and institutional arrangements?

- **Quality of Life**
  Does the technology create new highly-paid and prestigious employment, or the obverse? Does it facilitate ways of doing things? Does it change attitudes towards work and leisure and how these activities are organized? etc.

2.4/ In Sum

These criteria provide the framework within which the assigned and other technologies were evaluated. The evaluation framework is shown in Table 1.

There is a plethora of technologies that could be reviewed using this methodology. For example, the exhaustive list of technologies listed in the latest U.S. National Research Council five-year outlook on science and technology could be evaluated for Ontario following this methodology [1].

Table 1/ The Evaluation Framework

Technological Context			Economic/Industrial Context			Social Context				
	Technological Status					Acceptance			Impact	
Technological Candidate	International Strength	Ontario Capability	Comparative Advantage	Sector	External Influence	"Comfort Factor"	Capital Requirement	Policy Environment	Transformative Potential	Quality of Life

3/ THE TECHNOLOGIES

The technologies examined are more generic technological areas than they are specific technologies. As such, each area is comprised of a number of specific technologies that could have some significance for Ontario. These specific technologies could be further subdivided into component technologies. But for the purposes of this overview, subdivision will stop at the level indicated in Tables 2 to 9, which summarize the evaluations of the various technological areas.

3.1/ Aerospace

Aerospace activity in Canada is centred around Toronto and Montreal, with Ontario having more than 40% of the employment in the sector. As indicated in Table 2, Ontario has certain strengths in specialized areas, such as the DASH-7 aircraft and communications satellites. These are areas that receive adequate government support because of the export potential and the highly-skilled employment that is generated. Also, the capital requirements of the sector are moderate ($10 to $50 million/year), which means that financing can be arranged relatively easily compared to other sectors (e.g., energy mega-projects) [2]. Military procurements also bring work in specialized areas to Ontario firms.

The increasing use of satellites for communications purposes presents the largest potential, in this sector, for transformative change, by improving communications and multiplying information/entertainment channels (e.g., Pay-TV, direct broadcast to home, etc.). Also, new possibilities for specialized employment and regional development could develop. For example, Barbados is now offering key-punch services to New York City firms via satellite. Such international division of work could result in major employment displacement, requiring retraining for ever higher skill levels.

Ontarians want access to the world, as was demonstrated in the 1980 direct-to-home broadcasting pilot project in northern Ontario, managed by TV Ontario. People in remote communities felt less isolated [3]. Of course, since a number of U.S. satellites also beam programmes into Canada, people will receive more and more diversified programming in the future. And more and more people will have access to this programming as

Table 2/ Aerospace

Technological Context			Economic/Industrial Context			Social Context				
Technological Candidate	Technological Status		Comparative Advantage	Sector	External Influence	Acceptance			Impact	
	International Strength	Ontario Capability				"Comfort Factor"	Capital Requirement	Policy Environment	Transformative Potential	Quality of Life
Aircraft	advanced in U.S. and Europe and developing in newly-industrializing countries(NICs) (e.g., Brazil)	significant in selected areas (e.g., DASH-7)	significant in "niches"	transp	much competition	good	moderate	support	nil	highly-skilled employ.
Airframe	advanced in U.S. and Europe	limited: assembly	limited	transp	much competition	limited	moderate	limited	nil	skilled employ.
Engines	advanced in U.S. and Europe (also, Pratt & Whitney Aircraft of Canada Ltd. in Quebec)	limited	limited	transp	much competition	limited	moderate	limited	nil	skilled employ.
Avionics	advanced in industrialized countries	significant in specialized areas	good in "niches"	transp	highly competitive	good	small to moderate	support	nil	highly-skilled employ.
Satellites	well developed in industrialized countries	significant	good in comm. satellites	comm.	moderate competition	good	moderate	support	significant by facilitating comm.	new comm. options and skilled employ.

the price of receiving dishes tumbles below $500 per unit. The social and cultural consequences will be far-reaching. Will this new technology lead to a society of discriminating viewers because of the choice available, or to a more homogeneous society wanting U.S. programming and accepting the associated values? Some fundamental shifts in cultural values can be expected in Ontario within the next 25 years, as a result of the increasing use of communications satellites.

3.2/ Biotechnology

Biotechnology is both an old and new technological area, since fermentation and genetic manipulation are found under this rubric (Table 3). Of course, the most exciting area, one which has significant social ramifications, is the area of genetic manipulation. Ontario's position in this area is currently embryonic in nature [4].

While Ontario's comparative advantage is limited at the present time, it could develop rapidly in the next few years through Allelix Inc., the company established by the Canada Development Corporation (CDC), Labatts Ltd. and the Ontario government, in which these partners have invested $100 million over 10 years. The aim of this venture is to develop commercial biotechnology products and processes within this time frame.

Genetic manipulation has sparked an international debate on the legal and moral implications of creating new life forms. Some fear that new genes could cause unexpected and detrimental effects that could upset the natural order. Others see only benefits for mankind (e.g., cure for cancer, new food sources, etc.).

For example, the dilemma is reflected in the first Canadian genetic patent, recently given to Abitibi-Price Inc. of Toronto for its invention of a yeast culture that consumes the impurities in waste liquor produced in the manufacture of wood pulp -- impurities which are often dumped in Ontario rivers. It is difficult to see the negative aspects of so worthy an invention. But this first genetic patent is raising a number of questions regarding the kinds of guidelines that should be set in place in this area.

Table 3/ Biotechnology

Technological Context			Economic/Industrial Context			Social Context				
Technological Candidate	Technological Status		Comparative Advantage	Sector	External Influence	Acceptance			Impact	
	International Strength	Ontario Capability				"Comfort Factor"	Capital Requirement	Policy Environment	Transformative Potential	Quality of Life
Genetic Manipulation	developing rapidly	embryonic	limited but could develop	broad	much competition	moderate	moderate	support	significant	significant
Leaching	advanced in industrialized countries	embryonic	limited	mining	competitive	limited	small	positively inclined	nil	limited
Fermentation	mature technology	mature (breweries & wineries)	good	food & agric; also, energy	limited influence	good	moderate	support	nil	limited

Since genetic engineering is now beginning to develop in Ontario, this province could become a focal point for public debate.

3.3/ Nuclear Energy -- Fission/Fusion

Growing urbanization as well as industrialization requires more important sources of electrical energy. In Ontario, the major hydro sources are nearly exhausted, so nuclear energy presents the best option, given the potential of the CANDU reactor with its natural uranium cycle and its natural extension to the thorium cycle (Table 4). Building new coal-thermal plants presents major environmental problems (i.e., acid rain).

Among the nuclear reactor options, the CANDU is the accepted technological winner. However, like other nuclear reactors, taking the CANDU route requires a major capital investment, which means that governments become deeply involved. Decisions concerning nuclear reactors are very political, not only for financial and associated employment creation reasons, but also because of public unease about nuclear energy.

Ontario Hydro is committed to nuclear energy and the CANDU option. Some $24 billion has been set aside for nuclear expansion for the 1978 to 1988 period. However, while export sales of electricity to the U.S. are attractive and possible, the nuclear industry needs export sales of CANDU reactors to survive. The nuclear industry is currently at a low ebb, with 14 000 direct jobs, compared to 31 000 direct and 85 000 related jobs only seven years ago.

The CANDU's natural uranium cycle lends itself to exchanging thorium, a plentiful natural resource, for uranium. This would be the next logical step in CANDU's history. To demonstrate the feasibility of this cycle would necessitate an investment of some $2 billion [5]. A commitment to such a project would indicate that a firm decision to "go nuclear" is being taken, with the expectation that major uncertainties related to reactor safety, waste disposal, etc., would be overcome. The moral and ethical questions related to a long-term commitment to nuclear energy would have to be debated publically.

Table 4/ Nuclear Energy -- Fission/Fusion

Technological Context			Economic/Industrial Context			Social Context				
Technological Candidate	Technological Status		Comparative Advantage	Sector	External Influence	Acceptance			Impact	
	International Strength	Ontario Capability				"Comfort Factor"	Capital Requirement	Policy Environment	Transformative Potential	Quality of Life
Natural Uranium Cycle	limited	strong with CANDU	significant	electricity	export potential of elec. to U.S., and CANDUS abroad	good among elites but reservations in the public	very large	support	nil	clean energy source & skilled manpower
Thorium Cycle	limited	Research and Development (R & D)	good	electricity	limited	good extension of uranium cycle	large	moderate	nil	same as above
Radioactive Waste Disposal	limited	limited	good (large geographical area & new tunnelling technology)	mining	limited	limited	large	neutral at present	nil	comfort of knowing of safe disposal
Fusion	large programmes in U.S. and U.S.S.R., particularly	limited (some areas possible, e.g., lasers)	very marginal	energy	intense competition	limited	small in specialized areas (e.g., lasers)	moderate	nil	clean energy & skilled manpower (but nil in study time frame)

The public would be immensely reassured if nuclear waste could be disposed of safely. This remains an engineering challenge, but given the large expanse of stable rock structure in Ontario's Canadian Shield, it is not an insurmountable problem to find places where nuclear wastes could be stored for long periods. (These sites could also be used for the disposal of toxic chemical wastes.) Again, a large investment (about $500 million) would be needed to ascertain feasibility [5]. If feasible, nuclear waste disposal and management could become a major business for Ontario, if it accepts the nuclear wastes of other countries. But the public could find such a prospect socially unacceptable. Recent preliminary drilling tests in northern Ontario have generated an adverse public reaction.

Fusion is not an option, per se, for Ontario. Research programmes are too costly, and commercial feasibility is more than 25 years away. But Ontario could participate in certain aspects of U.S., European or Japanese programmes (e.g., laser technology and management of tritium) to have a "window" on international developments in the area. Such participation would cost some $10 to $20 million/year [6]. A small, Ontario- based, fusion, research and development (R & D) programme was recently announced. (A three-way agreement [National Research Council, Ontario government and Ontario Hydro] on a $15 million fusion, research and development project has been signed with the promise of another $21 million over the next five years [7].)

There are other energy options to generate electricity (e.g., wind and solar-photovoltaic), but these options remain largely unproven to generate the levels of electricity needed in the urbanized and industrialized society that is Ontario.

The main social implication of being committed to large-scale energy generation is being dependent on the societal organization, dictated by an electrical grid, except in the remote regions. If nuclear energy is developed fully in Ontario, it will be done through Ontario Hydro. Many tens of thousands of skilled jobs will result, as well as a clean source of electricity.

3.4/ Magnetics

Magnetism pervades as many areas as electricity, since the two are inextricably intertwined (i.e., Maxwell's electromagnetic theory). But for the purpose of this section, the focus will be on the potential of large magnets for a number of applications (Table 5).

The major applications of large magnets are at the experimental stage, with little commercialization potential and large-scale diffusion in the time frame of the study.

3.5/ Micro-Electronics

The micro-electronics revolution is pervasive. It is affecting every sector of the economy, especially the service sector. Applications are diffused throughout the economy very rapidly. Social acceptance is very high for certain applications (e.g., video games). And as shown in Figure 1, the sector experienced very high growth rates in Organization for Economic Co-operation and Development (OECD) countries in the 1960s and 1970s (i.e., the technologies in Quadrant 1, upper right corner, have experienced better than average growth rates). Industrialized countries are placing high hope on continued growth in the sector.

As with other sectors, the term micro-electronics is generic, and the sector is made up of the key sub-sectors shown in Table 6. Canadian strengths in the sector are in such specialized sub-sectors as telecommunications, office equipment and specialized instrumentation.

Socially, the transformative potential is highest in those areas which offer completely new ways of undertaking traditional functions, such as in the area of home and office equipment, which will deeply influence leisure and work patterns. The potential impact was summarized succinctly in a recent Science Council report [8]:

Table 5/ Magnetics

Technological Context			Economic/Industrial Context			Social Context				
Technological Candidate	Technological Status		Comparative Advantage	Sector	External Influence	Acceptance			Impact	
	International Strength	Ontario Capability				"Comfort Factor"	Capital Requirement	Policy Environment	Transformative Potential	Quality of Life
Fusion	linked to international fusion programmes	limited	nil	energy	much competition	nil	large	neutral	nil	nil (in study time frame)
Magneto Hydro Dynamic Power	large international programmes	limited	limited	energy	much competition	limited	moderate	neutral	nil	limited
Superconducting Generator and Motor	large effort internationally	limited	limited	energy	much competition	limited	moderate	neutral	nil	limited
Energy Storage	extensive international research	limited	limited	energy	much competition	limited	large	neutral	nil	limited
Levitation for Trains	international research and demonstration	nil	nil	transp	much competition	nil	moderate	skeptical (given past experience)	nil	moderate (better transportation)

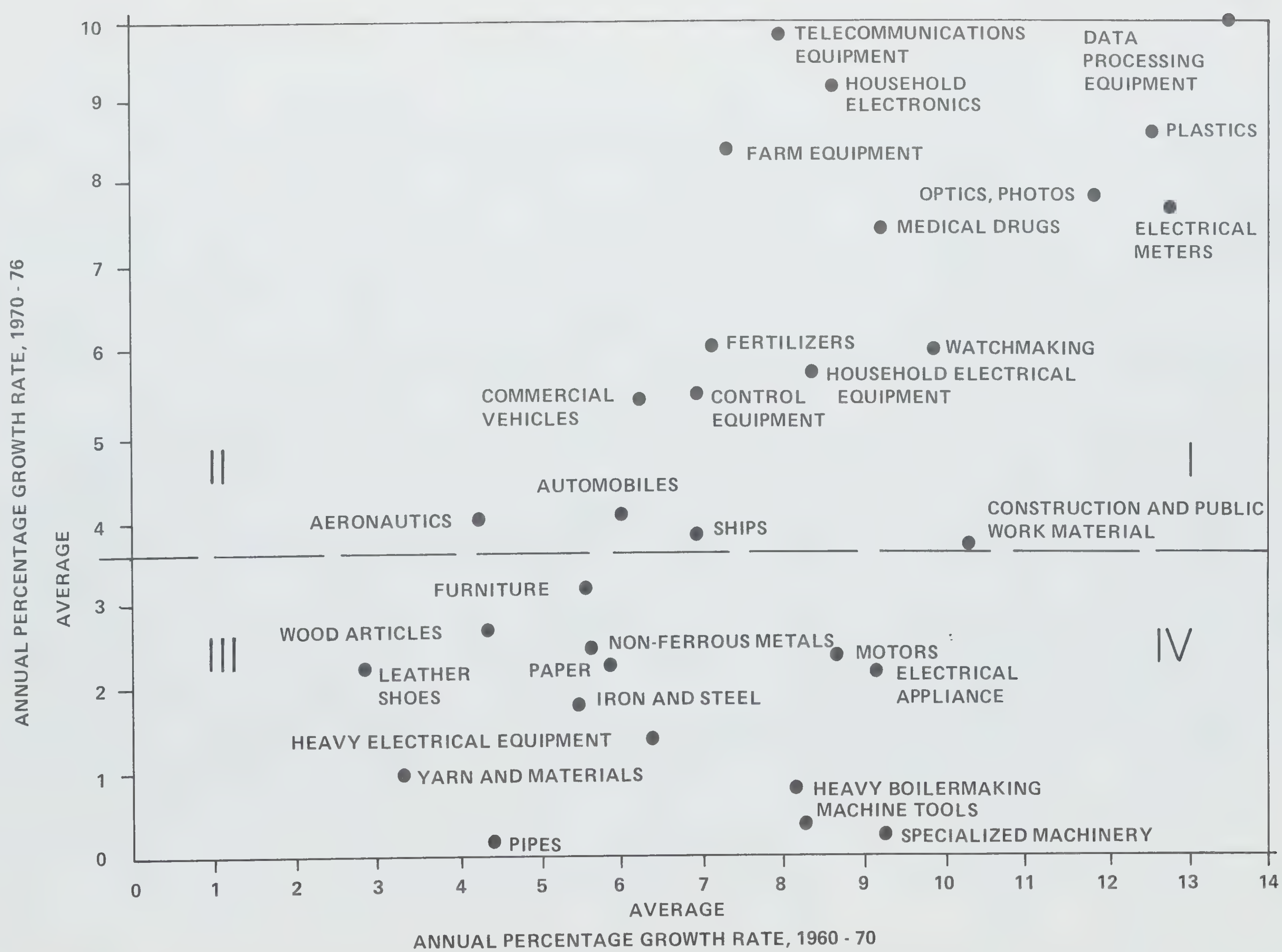

Figure 1/ Trends in International Demand for Manufactured Products, 1960 – 76
(Source: OECD, DSTI/IND/F19/80.22/Annex.)

Table 6/ Micro-Electronics

Technological Context			Economic/Industrial Context			Social Context				
Technological Candidate	Technological Status		Comparative Advantage	Sector	External Influence	Acceptance			Impact	
	International Strength	Ontario Capability				"Comfort Factor"	Capital Requirement	Policy Environment	Transformative Potential	Quality of Life
Consumer Electronics (e.g., TV sets)	Japan and some NICs	limited	declining	manuf.	highly competitive	moderate	moderate	positive	high	improved
Electronic Components (e.g., integrated circuits)	industrialized countries	limited	good in "niches" (e.g., customized circuits)	manuf.	highly competitive	good	moderate	very good	high	improved
Telecommunications (e.g., telephony data transmission)	industrialized countries	moderate	good in "niches" (e.g., N.T. switching technology)	manuf.	highly competitive	good	moderate	very good	high	improved (facilitation of communications)
Home & Office Equipment (e.g., terminals, word processors)	industrialized countries	moderate	excellent in "niches" (e.g. Mitel Corp.,AES Data Ltd)	manuf.	highly competitive	good	moderate	very good	pervasive	improved (higher skills needed)
Instruments and Systems Electronics (controls)	industrialized countries	limited	good in customized applications (e.g., Leigh Instruments Ltd.)	manuf.	highly competitive	good	moderate	good	moderate	improved

"From the shop floor to middle and senior management, computing power will displace human intelligence and computer memory will take the place of paper-based records, files and memos. Severe sectoral unemployment will result, with women, middle management and workers in manufacturing industries (many of them young with half their working lives ahead of them) first to feel the crunch. Extensive government-aided retraining programs will have to be undertaken by industry and educational institutions to fill positions in new job categories that are opening up. Software skills are in great demand today and the need for graduates who can program individual applications and design systems will grow throughout the decade. Co-operative approaches to labour/management relations must be developed to deal with the fear and distrust that will arise as the automated workplace comes into being.

The explosion of in-house computers, increased use of satellites by business and centralization of information could endanger our national sovereignty. Canada, a country still dominated by branch plants of multinational corporations, will have no legal jurisdiction over corporate information stored abroad.

The growing use of data banks threatens privacy. Data which by itself is considered nonsensitive can become sensitive when matched with other information in centralized files. Computers could increase the alienation and sense of powerlessness prevalent today or they could be used to increase and facilitate social interaction."

3.6/ Communications Technology

One topic that is very important for Ontario is communications technology (Table 7). It is important largely because Toronto is Canada's information/entertainment hub, and many Ontario-based firms serve this market.

Ontario has particular strengths in cable technology and interactive systems, with a developing strength in fibre optics technology, mainly through Northern Telecom. For example, Northern Telecom is considering entering into a 10-year, three-way, $100 million, fibre optics, research and development agreement with the federal and Saskatchewan governments.

Table 7/ Communications Technology

Technological Context			Economic/Industrial Context			Social Context				
Technological Candidate	Technological Status		Comparative Advantage	Sector	External Influence	Acceptance			Impact	
	International Strength	Ontario Capability				"Comfort Factor"	Capital Requirement	Policy Environment	Transformative Potential	Quality of Life
Broadcasting Technology	U.S. and Japan	limited	limited	service	highly competitive	limited	large	neutral	significant	access to the world
Cable Technology	Canada	strong	very good	manuf. & service	moderate	good	small to moderate	support	significant	more options
Fibre Optics Technology	U.S., Japan and Europe	moderate	emerging strength	manuf.	competitive	moderate	moderate	support	significant	more options
Interactive Systems Technology	Europe	strong	well positioned	manuf. & service	competitive	good	moderate	support	pervasive	work, education and leisure

This follows Saskatchewan's decision (and contract with Northern Telecom) to "wire-up" the province with optical fibre. Most of the basic research and development work will be undertaken in the Bell-Northern Research Labs in Ottawa.

Telidon technology is being transferred to the private sector, and new cable services are emerging (e.g., security systems, medic alert, Pay-TV, teleshopping, etc.). The new services multiply user choice, and interactive systems will change the work environment significantly. Work from the home and/or satellite offices becomes feasible, learning in one's own time becomes increasingly possible, and so on. The liberating potential is tremendous.

But like all technologies, it is a double-edged sword. It will become increasingly easy to monitor the tastes and activities of people. For example, monitoring a family's teleshopping channel will give a taste and expenditure profile to advertisers, who could then target more precisely their publicity campaigns. Similarly, cultural and political profiles could also be developed. The issue of privacy will take on new dimensions in the 1980s.

The liberating and constraining potentials will be at odds. What is acceptable to people will have to be continually assessed.

3.7/ Oceanography

The technologies related to our oceans (and to some extent, the Great Lakes) have to do with fisheries, exploration for resources, shipbuilding, military applications and sea-bed mining. These technologies are highly specialized and have limited social impact (Table 8).

From an Ontario perspective, the major impact is the economic potential and highly-skilled manpower needed in a sophisticated industry. While Canada's ocean industry is embryonic, a large number of the firms are in Ontario simply because of historical industrial development [9]. The offshore oil and gas potential offers major opportunities for this industry sector, which has, by and large, developed its expertise through military contracts. The transition to commercial applications will not

Table 8/ Oceanography

Technological Context			Economic/Industrial Context			Social Context				
Technological Candidate	Technological Status		Comparative Advantage	Sector	External Influence	Acceptance			Impact	
	International Strength	Ontario Capability				"Comfort Factor"	Capital Requirement	Policy Environment	Transformative Potential	Quality of Life
Fisheries Technology	industrialized countries	limited	limited	fishery	much competition	limited	moderate	neutral	nil	limited
Offshore Exploration Technology	U.S., U.K. and Norway	embryonic	emerging in selected areas	energy & minerals (i.e., nodules)	much competition	moderate	small to moderate	support	nil	limited
Shipbuilding Technology	Japan and some NICs (e.g., South Korea)	limited	emerging in Arctic shipping	resources	much competition	limited	moderate	support	nil	limited
Military Technology	NATO countries and U.S.S.R.	embryonic	good in customized areas (e.g., Fathom Oceanology Ltd)	manuf.	much competition	moderate	moderate	support	nil	limited
Sea-Bed Mining	U.S. and Europe	limited	moderate with Noranda Mines Ltd experience	mining	exploratory	limited	moderate (at present)	neutral	nil	limited within time frame

be easy, but the magnitude of the opportunity is so large (e.g., Hibernia development alone will cost \$6 to \$7 billion) that firms will adapt rapidly. The technological capabilities developed could eventually be applied to other areas, such as sea-bed mining, in the next century.

In the more immediate future, offshore activities will mean more economic activity and more skilled employment for Ontario.

3.8/ Robotics

Robots replace people. So, there is concern. On Japanese auto assembly lines, 98% of the welding is done by robots. Computer-Assisted Design and Manufacturing (CAD/CAM) is emerging as a potential threat to human skills. It is a real threat -- the operating cost for a robot is about \$5/h compared to the unionized worker at \$10 to \$20/h. And the robot does not take a coffee break, need a vacation or go on strike. So, it is no wonder that management will opt for investment in robots, as opposed to wage increases, particularly as micro-chip technology brings the price of robots down to the \$10 000 range by the 1990s, compared to \$100 000 per unit today.

Ontario has specialized expertise in this area (Table 9). Spar Aerospace Limited's "Canadarm" technology is being transferred from space to other hazardous environments, such as nuclear reactor refuelling and sea-bottom remote manipulation. In space, this technology could eventually become integrated into the development of space stations.

In the productivity enhancement technology area, a handful of firms (about 20) are working on specific components of robots (e.g., visual definition). But these developments can only be improvements on the robots Canada imports from Japan and, in particular, the U.S.

Ontario will continue to import robots -- it makes economic sense to do so. There may be social dislocations, at least in the short to medium term. Labour will likely resist the adoption of robotics technology. Canadian workers, unlike their Japanese counterparts, do not see technology as an ally. Labour resistance to technological challenge could become a major issue in the 1980s, eroding further labour/management relations, which are already tense.

Table 9/ Robotics

Technological Context			Economic/Industrial Context			Social Context				
Technological Candidate	Technological Status					Acceptance			Impact	
	International Strength	Ontario Capability	Comparative Advantage	Sector	External Influence	"Comfort Factor"	Capital Requirement	Policy Environment	Transformative Potential	Quality of Life
Hazardous Environment Technology	Japan and U.S.	significant	significant (e.g., Canadarm to customized areas)	manuf.	competitive	good	moderate to high	support	limited	improved (safety)
Productivity Enhancement Technology	Japan and U.S.	limited	emerging in selected areas	manuf.	highly competitive	moderate	small to moderate	support	significant	mixed (less rote but job displacement)

4/ TO USE OR NOT TO USE THE NEW TECHNOLOGY

Ontario is Canada's most important economic component: it accounts for about 40% of the country's GNP. Because it is Canada's most industrialized province, it has the country's most extensive scientific and technological infrastructure, which facilitates the implementation of new technologies. And because Ontario is the centre of Canada's open international trade system, it has to use technology to remain competitive.

However, the historical position of Ontario is being challenged from a number of quarters. The major influences are :

- the emerging resource strengths of Western and (soon) Eastern Canada;
- the shedding of consumer-goods manufacturing to the newly-industrializing countries (NICs) (e.g., South Korea and Brazil);
- new resource countries as competitors in the less-developed world;
- an increasing aggressiveness in high-technology areas in the advanced countries; and
- a lowering of tariff barriers (Tokyo Round of General Agreement on Tariffs and Trade [GATT]), combined with a shift in the U.S. economy from the North-East to the South-West, which means that:
  - Ontario can be served directly from the U.S. without the need for a branch plant, and
  - Ontario's traditional U.S. markets are in decline.

4.1/ Business-as-Usual

The authors believe that Ontario cannot adopt a "laissez-faire" stance. In the face of the major influences that are affecting its economic development, this could mean that the province would undergo a relative economic decline and be forced to accept the associated social impact, because it would be merely reacting to change and not shaping it.

In a deteriorating situation (i.e., de-industrialization), unemployment rises, the standard of living erodes, institutions (e.g., universities) are weakened, and so on, leading to social uncertainty. This uncertainty is already evident in certain sectors, such as the automobile industry, which is being rationalized internationally. For that industry to remain viable in Ontario, many more thousands of jobs will have to be shed in the next few years [10].

As industrial capabilities decline, the ability to implement new technologies becomes impaired, which means that, not only will skilled employment be scarcer, but skilled people will be underemployed in a number of areas because of the lack of positions requiring their skills.

Such a declining situation would be difficult to redress because of the structural changes that would occur. While an industry can be dismantled rapidly, it takes a long time to re-develop the capabilities needed to operate a competitive industry. For example, Canada's aerospace industry is only now re-emerging from the 1959 cancellation of the Arrow programme. And once firms have closed their doors, there is no guarantee that they will reopen in Ontario, because the initial locational advantages may no longer exist.

It has been said that under a business-as-usual situation, Ontario would evolve from a "branch-plant" to a "warehouse" economy, since distribution of goods from abroad would overtake manufacturing. With non-tariff barriers replacing tariff barriers, and the growing pressures on U.S. industry by the U.S. government and labour to stimulate industrial activity at home, disinvestment in Ontario is a real possibility. The "warehouse" economy, with all its social and economic implications (e.g., underemployment), may not be so far-fetched.

4.2/ An Aggressive Stance

In the face of the consequences of a "business-as-usual" approach, the authors recommend that Ontario set in place a technology-based industrial strategy to create those industries and the highly-skilled jobs that Ontarians will need to maintain their standard of living.

As the analysis of the previous sections indicates, Ontario has some emerging high-technology strengths in selected areas. Some of these are summarized in Table 10. Because most of these strengths are embryonic, they will need sustained government support. Even Northern Telecom, Canada's high-tech flagship, is only a medium-sized firm by international standards.

In many areas, government support is possible because capital requirements are not astronomical (Appendix C). And indeed, many areas where social impacts are likely to be most pronounced (e.g, communications, biotechnology and micro-electronics) are not as capital-intensive as other areas (e.g., nuclear energy) which do not have the same transformative potential. Social pervasiveness is not necessarily a corollary of capital intensity.

Ontario has begun, under its Board of Industrial Leadership and Development (BILD) programme, to support the development of new technologies. This is a necessary first step to the development of a high-technology industrial strategy which would support those areas that are the most socially acceptable in Ontario.

The social impact of implementing new technologies will be great. So will the impact of not implementing them. But by participating in industrial development, Ontarians are in a much better position to manage the impacts and shape the institutions that will be needed to manage the new technologies.

Table 10/ Selected Technologies with Areas of Technological Strength in Ontario (Adapted from Previous Tables)

Technology	Ontario Status	Social Impact	
		Transformative Potential	Quality of Life
Aircraft	significant in specialized aircraft (e.g., DASH-7)	nil	skilled employ.
Avionics	good in "niches"	nil	skilled employ.
Satellites	significant through Spar Aerospace Ltd.	significant by facilitating communications	new communication options affecting work and leisure
Genetic Manipulation	emerging through Allelix Inc.	significant	significant in medical and industrial areas (skilled employ.)
CANDU Reactor	leader through Ontario Hydro	nil	clean source of energy & skilled employ.
Telecommunications	good in "niches" (e.g., Northern Telecom)	high	improved communications & skilled employ.
Home & Office Equipment	good in "niches" (e.g., Mitel Corp. & NABU Manufacturing Corp.)	pervasive	improved lifestyle and skilled employ.
Military Technology	good in custom-areas (e.g., Leigh Instruments Ltd. & Fathom Oceanology Ltd.)	nil	limited: some skilled employ.
Customized Robots	significant with Spar Aerospace Ltd.	limited	safety & skilled employ.
Cable Communication Technology	strong	significant	broadens communication options
Fibre Optics Technology	emerging	significant	more channels possible
Interactive Systems	strong (e.g., Telidon)	pervasive	improved work, leisure, & education environment

5/ CONCLUSION

Ontario is facing major social impacts in the next 25 years. The only way to minimize, and possibly arrest, any negative impacts is to participate aggressively in the development of new technologies.

Ontario has technological strengths in selected areas. Some of these areas, such as communications technology and biotechnology, are likely to produce pervasive, yet manageable changes. Participation in the development of these technologies does not necessarily require very large capital investment and would generate the kinds of economic activity that Ontarians have come to expect.

Participation in the development of new technologies requires sustained government involvement, particularly in the initial stages of development. This is recognized in all industrialized countries and Ontario will have to do likewise, if technologies (acceptable in an Ontario context) are to be implemented. It is only through aggressive participation that the social impacts can be managed.

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Appendix A/ The Socio-Economic Structure of Ontario

	EMPLOYMENT (1981)[1]			GROSS DOMESTIC PRODUCT (1980)[2]		
Sector	(000s)	% Share of Provincial Total	Change in % Share Since 1966	Millions Constant (1971) Dollars	% Share of Provincial Total	Change in % Share Since 1961
Agriculture	142	3.4	- 2.1	741	1.6	- 1.3
Forestry & Fishing	9	0.2	- 0.2	127	0.3	- 0.1
Mining	48	1.2	-0.5	517	1.1	- 1.8
Primary Industries Total	199	4.8	- 2.8	1 385	3.0	- 3.2
Manufacturing	1044	24.9	- 8.7	12 930	28.5	+ 2.0
Construction	217	5.2	- 0.9	1 673	3.7	- 2.5
Secondary Industries Total	1261	30.1	- 9.6	14 603	32.2	- 0.5
Utilities, Transportation and Communications	300	7.2	- 0.6	4 675	10.3	+ 1.4
Wholesale & Retail Trade	678	16.3	- 0.5	5 429	12.0	+ 0.4
Finance, Insurance and Real Estate	250	6.0	+ 0.9	6 643	14.7	+ 1.2
Community, Business and Personal Service	1223	29.5	+ 6.2	9 687	21.4	+ 2.7
Public Admin. & Defence	273	6.9	+ 0.5	2 886	6.4	- 2.8
Tertiary Industries Total	2724	65.7	+ 5.4	29 320	64.8	+ 2.9

Sources: [1] Statistics Canada, [2] Conference Board of Canada

Appendix B/ Rationale for Assumptions

The previous analysis rests on four fundamental assumptions (in the introduction), which are seen as underpinning the evolution of Ontario society in the next 25 years. The rationale for these assumptions will now be discussed.

1/ Ontario will continue to be of a "technology push" nature (i.e., an advanced industrial society).

The obverse of this assumption is the development of a non-industrial, small-community-oriented society accepting "conserver society" principles. The level of urbanization and industrialization in Ontario is too great to have a massive social shift to societal arrangements that would be significantly different. There likely will be experimentation with alternative lifestyles, but these experiments will, at best, only have marginal social effects, because of the inertia within Ontario society.

2/ Most of the technologies to be implemented are already in existence.

It takes a very long time for a technology to reach the level of diffusion necessary to generate a pervasive social change. Research and development can take a decade, and commercialization and diffusion another decade. Of course, specific applications of a technology, such as in the micro-electronics sector, can be implemented rapidly (e.g., video games) once a technology has reached a level of maturity to permit this. For example, the Josephson junction, which was discovered in 1961, is only now being applied in micro-electronic devices in a serious way.

Therefore, while it is possible for an unpredicted revolutionary technology to appear, it will take time for it to diffuse through the social fabric of a society. The impact of completely new technologies on Ontario society would be limited and would not affect the conclusions of this study greatly.

3/ Ontario's socio-economic structure will not change dramatically.

The increasing volatility of the international political/economic system could undermine this assumption. World recession and the associated industrial retrenchment is not only creating massive unemployment, but affecting the resilience of the Ontario economy. As firms close, there is no assurance they will reopen, and if they do, they may start up elsewhere (e.g., U.S.) because of locational advantages. Therefore, our "business-as-usual" option, which is one of slow decline, could give way to <u>rapid</u> decline and the attendant social impacts (e.g., massive unemployment and underemployment, social unrest, eroding standard of living, and so on). Rapid decline is not out of the question, given current international economic conditions.

4/ Ontario society will continue to exhibit values typical of Western industrialized democracies.

This follows on the first assumption. Western values are too deeply entrenched in Ontario society for alternative value systems to have a major impact within the next 25 years. Even in a "rapid decline" situation as postulated above, Ontarians would continue to seek solutions to their major problems through traditional democratic institutions (e.g., Parliament). Few would advocate alternative approaches to societal organization (e.g., world government, or the opposite stance of no government).

5/ In Summary

Therefore, there appears to be only one major challenge to the assumptions on which this study is based -- the volatility of the international political/economic system. But even within a world of growing international uncertainty, Ontarians will continue, by and large, to solve their problems in ways that follow accepted social customs.

However, given the possibility of growing international uncertainty, Ontario will need to become more "self-sufficient" to cushion itself against those events it cannot control.

Appendix C/ Capital Requirements Associated with the Development of New Technologies

The capital requirements associated with the development of new technologies, such as those reviewed in this study, can vary greatly (Table C-1).

While these numbers are only illustrative, they indicate the following.

- A well-established, successful firm can usually manage its conventional capital investment programme.
- New projects usually require some government support because of the risk involved.
- Government support is usually easier to obtain if the amounts involved are small to moderate and benefits can be foreseen in a more immediate future.
- Government support is more difficult to obtain if risks are high, benefits distant, or the area ill-defined.
- Public debate will grow with the level of public investment and public profile of the technology (e.g., nuclear energy).

As a rule of thumb, the mega-project threshold ($100 million project cost) seems to trigger a different level of public reaction and debate. For example, micro-electronics, communications and biotechnology, which are bound to have much more profound impacts on Ontario society than nuclear energy or the Suncor purchase, are not as actively debated publicly. They are not as visible because capital investment is gradual. The public/-political perception of the social impact has a profound influence on the implementation of a technology. And that perception may have little to do with the actual impact that the technology will have.

This capital investment profile indicates that Ontario could go a long way in selected new technological areas (most of those shown in Table 10), with limited investment. However, full-scale development in certain areas could go well beyond the levels indicated. For example, if Ontario decided that to increase manufacturing productivity rapidly, it would assist in a major programme of conversion to robotics, then such a programme could well require an investment of $100 million per year, initially. Such a major investment would, of course, raise the public profile of the programme.

A strategy that gains public acceptance for a technology gradually and that permits better management of the social impacts should be the preferred option. An industrial strategy stressing the development of strengths could require a large investment, overall, if it is to be at all comprehensive. For example, the Quebec government has admitted that some $1 billion will be needed in the next four years to implement its recently-announced industrial strategy which emphasizes high-technology [11].

Table C-1/ Capital Requirement Levels of New Technology Projects

Project Area	Capital Requirements	Key Actors
Aerospace	moderate: $10-$50 million/yr in Ontario sector of the industry.	Private sector supported by government contracts. Larger government participation is exploratory programmes (e.g., Canadarm).
Biotechnology	small to moderate: small projects at the $100 000 level have been initiated. Allelix Inc. is $10 million/yr for 10 years.	Private sector through the market mechanism (e.g., Bio Logicals Inc.) or in partnership with government (e.g, Allelix Inc.for riskier ventures)
Nuclear Energy	very large: Atomic Energy of Canada Ltd.'s (AECL's) current total budget is $358 million/yr. Thorium cycle feasibility would be $100 million/yr over 20 years. Even participation in an international fusion programme would cost $10-$20 million/yr over 25 years.	Government leadership needed because of high level of sustained investment needed. Industry is a supplier to Ontario Hydro.
Magnetics	moderate: projects require from $1-$20 million/yr in R & D funds.	Area is in the R & D phase, requiring substantial government support.
Micro-Electronics	small to moderate: say $100 000 to $10 million/yr.	Private sector leader -- through normal market mechanisms.
Communications	moderate: $1-$20 million/yr. For example, Northern Telecom agreement with federal and Saskatchewan governments is $10 million/yr for 10 years.	Many areas with immediate benefits can be privately funded (e.g., pay-TV). Developmental areas (e.g., fibre optics) require government involvement.
Oceanography	moderate: $1-$100 million/yr. For example, Dome Mines Ltd. is proposing to build a $300 million shipyard over 3-4 yr. Noranda's participation in sea-bed mining consortium was $1 million/yr.	Level of sophistication and risk requires government involvement and support (e.g., fiscal incentives, regulatory users).
Robotics	small to moderate: $100 000 to $5 million/yr.	Private sector can finance projects through market mechanisms.

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